

**A Study of the Environmental Performance on  
Hazardous Waste Management of the Semiconductor  
and Electronics Industries in Selected Industrial  
Estates in Luzon, Philippines**

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EEPSEA was established in May 1993 to support research and training in environmental and resource economics. Its objective is to enhance local capacity to undertake the economic analysis of environmental problems and policies. It uses a networking approach, involving courses, meetings, and technical support, access to literature and opportunities for comparative research. Member countries are Thailand, Malaysia, Indonesia, the Philippines, Vietnam, Cambodia, Lao PDR, China, Papua New Guinea and Sri Lanka.

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# **A STUDY OF THE ENVIRONMENTAL PERFORMANCE ON HAZARDOUS WASTE MANAGEMENT OF THE SEMICONDUCTOR AND ELECTRONICS INDUSTRIES IN SELECTED INDUSTRIAL ESTATES IN LUZON, PHILIPPINES**

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## **EXECUTIVE SUMMARY**

In the Philippines, the semiconductor and electronic industry contributes about 70% of export earnings. More than half of the companies inside industrial estates in the country are semiconductor and electronic firms. These firms are among the major contributors of hazardous wastes released through different media, notably solid and semi-solid wastes. The environmental performance indicator, amount of hazardous waste generated per employee, was selected in this study since it is the main environmental problem of SEF and it can be a surrogate of environmental performance when the volume generated has been reduced by way of treatment, disposal or waste minimization efforts.

A model equation was derived which identifies the 10 significant variables in terms of affecting the hazardous waste generation. Out of the 10, only four were found to be significant to reduce or increase amount of hazardous waste generated. These are a) ISO accreditation, b) price of treatment and disposal, c) location of firm, whether inside an industrial estate or not, and, d) number/frequency of inspection by regulatory agency.

From the regression results, it was shown that there would be less hazardous waste generation if the firm were more automated with less number of employees. Proper handling and transporting of raw materials and products to minimize waste, increasing quality control to minimize rejects, and recycling could also reduce waste generation. Price has also an effect in that increasing the cost charged by ESPs could result to a substantial reduction in hazardous waste generation, which was found to be price elastic. The location of the SEF was also found to be a significant variable since SEF located inside an industrial estate appear to produce more hazardous waste perhaps because the SEFs inside the IEs are more transparent in reporting compared to their counterparts outside IEs. More frequent inspection was also shown to positively affect the environmental performance by reducing hazardous waste generation. Thus, as in other types of industry, inspection is a powerful tool in improving environmental performance within the semiconductor and electronic industry.

## 1.0 INTRODUCTION

Over the past twenty years, the Philippines had been experiencing a transition from agricultural to industrial economy. Significant policy and structural reforms were implemented for the purpose of opening up the economy in the early 1990s by attracting foreign and local investments to the country. Export promotion gained significant attention, as it was perceived to be the immediate solution to the debt-burdened economy.

As such, fiscal and non-fiscal incentives were extended to export-oriented industries, coupled with the relaxation of foreign ownership. Moreover, geographical areas in the country were dedicated to host these industries, extending various privileges to tenant companies. Such areas, called industrial estates or ecozones, were intended to boost industrial activities both in the urban and rural communities. There are about 137 industrial estates (IE) in the Philippines with about 886 locators or firms.

The large contribution (>70%) from export earnings of the semiconductor and electronic firms (SEF) has to some extent resulted in favorable incentives to these industries compared with others. Huge investments in the semiconductor and electronic industries started to pour into the country and their numbers began to grow. More than half of the firms inside industrial estates in the Philippines are SEF. Currently there are approximately 576 firms – with 398 located inside industrial estates and 178 firms outside.

Semiconductor and electronic industries include the manufacturing of passive components (resistors, capacitors, inductors); semiconductor components (discretes, integrated circuits); printed circuit boards (single and multilayer boards); and printed wiring assemblies. These industries, however, are among the major contributors of hazardous wastes released through different media.

Potential air emissions from manufacturing of semiconductor and electronic products include toxic, reactive, and hazardous gases. Such gases include sulfuric, hydrochloric, phosphoric, nitric, acetic, and other acids; chlorine, ammonia, and organic solvent vapors. Effluents resulting from the manufacture of these products, however, may contain heavy metals like copper, nickel, iron, chromium, tin, lead, and palladium. Solid wastes such as mould runners and electroplating sludges, on the other hand, may include heavy metals, solder drops, arsenic, plating and hydroxide sludges, inks, among others.

In light of the growing concern about the ecological risks posed by hazardous wastes in the country, as well as the Philippine commitment to the Basel Convention on the Transboundary Movement of Hazardous Wastes, it is imperative to review the factors that influence the generation of such waste from the semiconductor and electronic industries and how it reflects on their environmental performance.

The main objective of this study was to develop an environmental performance indicator using relevant economic and environmental parameters in relation to hazardous waste management within industrial estates. The study will focus on the semiconductor and electronics industries located in industrial estates in Luzon, with a comparative study on those located outside the industrial estates.

The study attempted to address the following key questions:

(1) Using an environmental performance index, is there a difference in environmental performance between the three sets of ecozones and locators? In case a difference is observed, what are the contributing factors that could be attributed to such?

(2) What are the incentives between locators and ecozones, locators and ESPs, and from the Philippine Department of Environment and Natural Resources for industries to be compliant with hazardous waste management regulations?

While the original intention was to develop an index, it became obvious later that it was best to limit the study to using only one indicator to determine environmental performance. Being the most significant with the SEFs, hazardous waste generation per employee was selected as a logical indicator of environmental performance. The next steps were to select and test independent variables and how they have any impact on hazardous waste generation.

## 2.0 PROFILE OF SEMICONDUCTOR AND ELECTRONICS INDUSTRY IN THE PHILIPPINES

It is estimated that there are 576 semiconductor and electronics firms nationwide as shown in Figure 1 and Figure 2 (PEZA 2001, BOI 2001, UP 2002). About 522 or 91% of semicon & electronics companies are in Luzon as shown in Figure 3. Of these, around 398 or 66% are inside industrial estates and 178 firms or 34% are outside industrial estates. There is a wide variation in the data for semicon firms outside the IE. From a compiled list of 436 semicon and electronic firms located outside industrial estates, only 178 were found still operational but mostly manufacturing various electrical products. Their latest coordinates were known with the help of the telephone directory and follow up calls. There are discrepancies in the records of government agencies such as DENR, PEZA and BOI so a different number may also be reported in other literature.

The Semiconductor and Electronics Industry of the Philippines, Inc. (SEIPI), the semicon association, reports 575 SEFs with 361 of them inside industrial estates and 214 located outside industrial estates. The breakdown in Figure 1 appears to be close to these figures compared to data from government agencies.

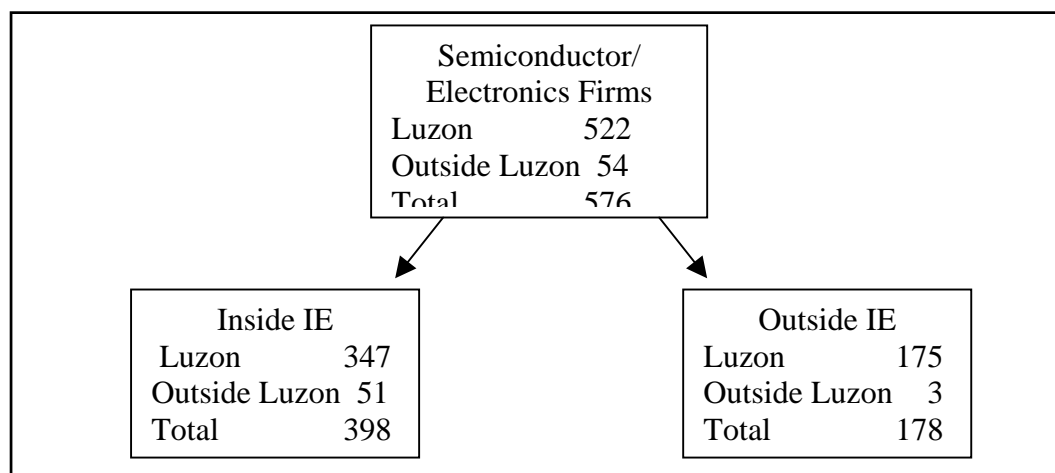


Figure 1. Distribution of Semiconductor and Electronics Firms in the Philippines



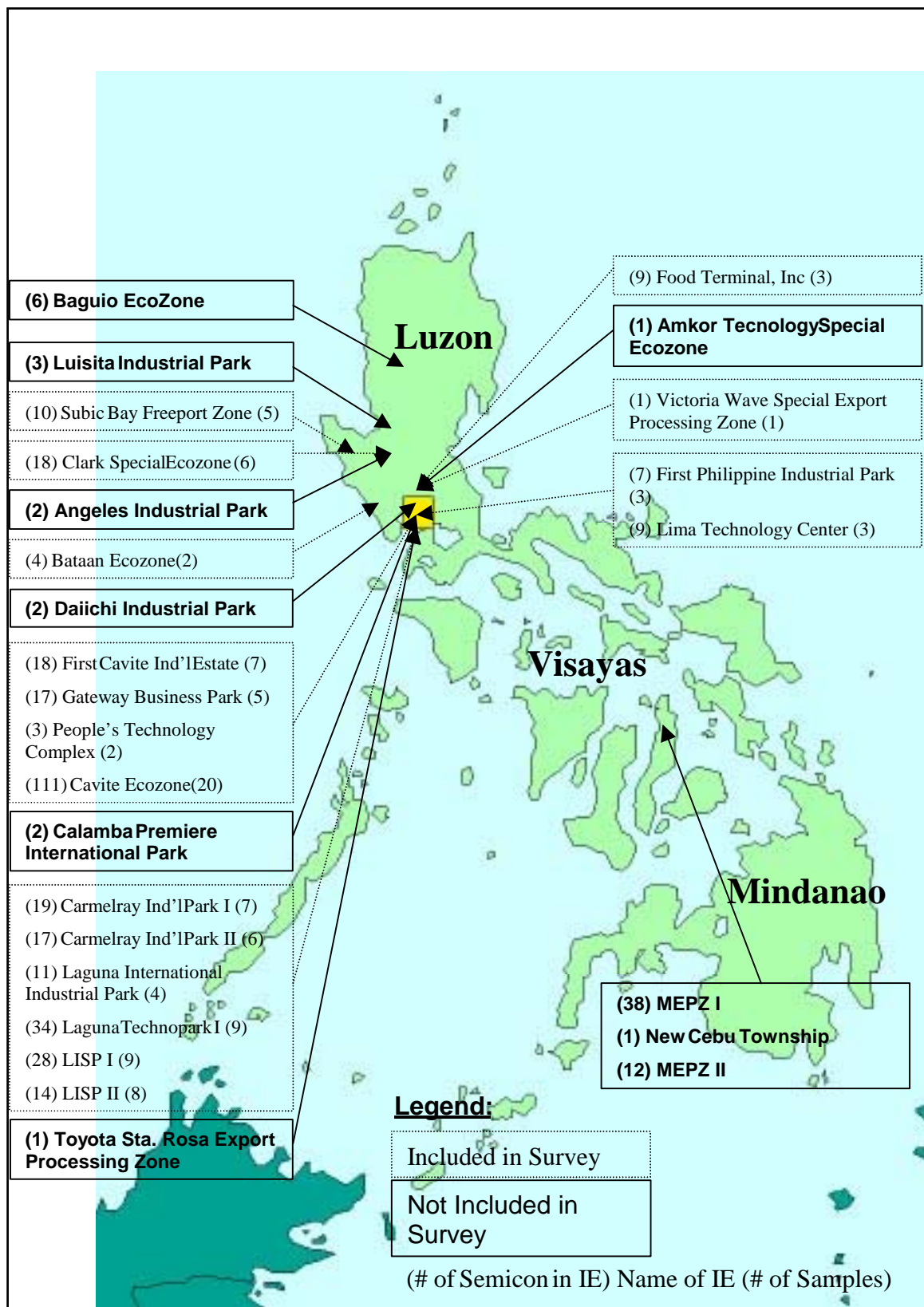


Figure 2. Location of Industrial Estates with Semiconductor and Electronics Firms in the Philippines



Figure 3. Location of Semiconductor and Electronics Firms Outside Industrial Estates in the Philippines

### **3.0 REGULATIONS AFFECTING THE SEMICONDUCTOR AND ELECTRONICS INDUSTRY**

This chapter provides an overview of the institutional arrangement and the environmental regulations presently enforced in the Philippines as they affect the operation and performance of the semiconductor and electronics industry.

#### **3.1 Institutional Arrangement Related to Enforcement of Environmental Regulations**

The environmental regulatory framework for the semiconductor and electronics industry involves three major government agencies, namely, the Department of Environment and Natural Resources (DENR), Laguna Lake Development Authority (LLDA), and the Philippine Economic Zone Authority (PEZA).

The DENR, through its Environmental Management Bureau (EMB), is the agency in-charge of implementing the national environmental laws in the country. The effluent discharges of a semiconductor and electronics industry that is situated within the Laguna Lake basin is regulated by the LLDA, which is an attached agency of DENR. However, regulations pertaining to hazardous waste management lies within the mandate of the DENR.

PEZA has been attracting investors and providing support to locators inside an IE in terms of project development, administrative and regulatory compliance and environmental management. PEZA was established in 1995 by virtue of Republic Act 7916 specifically to accelerate the creation of employment opportunities, spur the growth and diversification of exports, attract foreign investors and develop world-class and environment-friendly economic zones.

There are also other public and private sector agencies that influence the semiconductor and electronics industry, such as:

- Department of Trade and Industry– Board of Investments (DTI-BOI)
- Semiconductor & Electronics Industry of the Philippines, Inc. (SEIPI)
- Pollution Control Association of the Philippines, Inc. (PCAPI)
- Industrial Estates (both publicly- and privately-owned).

Both SEIPI and PCAPI, having pollution control officers of each firm as members, are industry associations that serve as networks for the semiconductor and electronics industry in upgrading management skills accelerating technological developments, and communicating recent environmental guidelines and waste management alternatives. SEIPI and PCAPI hold conferences, seminars and trainings for members related to recent developments in the industry.

The IEs are required by PEZA to set-up environmental facilities and utilities that include wastewater collection, treatment, disposal and recycling of wastes. Guidelines are developed by PEZA for the IEs to follow. To attain environmental compliance, the IEs, on the other hand, also regulate the environmental performance of its locators.

PEZA monitors compliance of IEs by requiring locators to submit copies of: (a) Pollution Control Officers' monitoring reports and results of effluent analysis, (b) permits from the DENR or LLDA for the wastewater treatment facility and air pollution control devices, (c) permits of waste transporter, treater/storage facilities, and (d) Environmental Compliance Certificate. At least once a year, government inspectors visit to validate reports submitted by the locators.

### 3.1 Relevant Environmental Regulations

Table 1 provides a summary of the relevant regulations that apply to the semiconductor and electronics industry while Table 2 describes the framework of the general regulations and the implementing agency.

Table 1. Summary of Relevant Regulations

<i>Applicable Regulations</i>	<i>Main provisions</i>
RA6969, DAO 92-29	Disposal and storage requirements of hazardous waste
PD 1586, DAO 96-37	EIA/ECC compliance monitoring
RA 8749	Banning of incinerators as a means to dispose hazardous waste
DAO 94-28, DAO 97-28	Ban on importation of goods with hazardous component
RA 9003	Waste reduction, segregation and recycling
RA 7916	Mandates PEZA to protect the environment within IE

The major environmental law relevant to hazardous waste management in the Philippines is Republic Act 6969 - Toxic Substances and Hazardous and Nuclear Wastes Control Act of 1990 and its implementing guidelines DAO 29. Compliance is monitored by the DENR-EMB.

In subsequent administrative orders issued by the DENR (92-29 and 97-28), registration, permitting and reporting requirements, and penalties were imposed by DENR. Specifically, industries are required to undertake the following:

- a) Waste minimization and recycling as the top priorities in the order of preference for hazardous waste management programs.
- b) Classification of hazardous wastes
- c) Minimum requirements on hazardous waste generators including notifying, reporting, planning, and training
- d) Permitting program for transporters and requirements for generators to use authorized transporters only.

Table 2. General Regulations Governing Hazardous Waste Management

<i>Major Laws/Regulations</i>	<i>Legislative Framework</i>	<i>Implementing Institution/ Monitoring System</i>
Republic Act No. 6969 - Toxic Substances and Hazardous and Nuclear Wastes Control Act of 1990 and DENR Administrative Order No. 29, 1990 (IRR of RA6969)	An act to control the importation, manufacture, processing, sale, distribution, use and disposal of toxic substances and hazardous and nuclear wastes.	Department of Environment and Natural Resources – Environmental Management Bureau (DENR-EMB)
DENR Administrative Order Nos. 94-28 and 97-28	Importation of foods with hazardous component	DENR-EMB
The Pollution Control Law (Presidential Decree No. 984) and  DENR Administrative Order Nos. 34 and 35	National policy to prevent, abate and control pollution of water, air and land.  Provides the Effluent Regulations of 1990	DENR-EMB (applicable nationwide except for areas within LLDA jurisdiction)
LLDA Resolution No.25	Implementation of the Environmental User's Fee System within the Laguna Lake basin.	LLDA
EIS System (Presidential Decree 1586) and DENR Administrative Order No., 96-37	Environmental Impact Statement System	DENR
Philippine Clean Air Act of 1999 (RA No. 8749)	Development of air quality management system	DENR-EMB and its regional offices

- e) Use of a Waste Transport Record to track the movement of hazardous wastes from the source of generation to the ultimate disposal location.
- f) Requirements on hazardous waste storage and labeling of vessels, containers, and tanks
- g) Categories of waste management premises and permitting requirements for waste treatment, storage, and disposal facilities.
- h) Ban on importation of goods with hazardous component.

New industrial projects are required to undertake an Environmental Impact Assessment (EIS) by virtue of the Environmental Impact Statement (EIS) System in PD1586. This would require a project to secure an Environmental Compliance Certificate (ECC) from the DENR prior to its operation. Conditions relative to hazardous waste management are indicated in the ECC and monitored by the DENR as well as IEs.

In terms of waste disposal in the Philippines, incineration is not acceptable as stipulated by RA 8749 – Philippine Clean Air Act. Therefore, hazardous wastes of the semiconductor and electronics industry are currently stored onsite or disposed through DENR-recognized Environmental Service Providers (ESPs). RA 9003 encourages waste minimization, segregation and recycling.

In August 1999, there was a Memorandum of Agreement (MOA) between PEZA and DENR, which states that PEZA will assist DENR in monitoring the environmental compliance of locators. Up to this writing, this MOA is not yet in effect since the implementing guidelines have yet to be drafted.

### **3.1 Applicability of Environmental Regulations to Firms Within or Outside an Industrial Estate**

Locators outside IEs are monitored by DENR and LLDA while the locators inside IEs have the four agencies to deal with : the IE-Environmental Units, PEZA, DENR and LLDA thus making them more compliant.

A more detailed listing can be found in Tables 3 to 5 with the relevant provisions of each law to management of hazardous waste management applicable whether a firm is located inside or outside an industrial estate. Table 3 specifies the major regulations specific to hazardous waste management, while Table 4 presents inspection and monitoring practices with Table 5 presenting guidelines for treatment, storage and disposal of hazardous wastes.

Table 3. Regulations Governing Hazardous Waste Management as Applied to Firms Located Inside and Outside IEs

<i>Major Laws/Regulations</i>	<i>Applicability to Firms Inside IE</i>	<i>Applicability to Firms Outside IE</i>
Republic Act No. 6969 - Toxic Substances and Hazardous and Nuclear Wastes Control Act of 1990 and  DENR Administrative Order No. 29, 1990 (IRR of RA6969)	IE requires firm to secure clearances for HW storage, transport and disposal.  Contracted ESPs should present valid DENR clearances to IE prior to transport/off-site disposal  Firms required to submit monitoring reports to EMB cc: IE  IE reviews monitoring reports  IE forwards copy of monitoring reports to PEZA-Environmental Unit  IE conducts on-the-spot check on environmental compliance of firm.	Firms submit monitoring reports to EMB  Firms secure clearances for HW storage, transport and disposal from EMB.

(continued)

Table 3. continued

DENR Administrative Order Nos. 94-28 and 97-28	IE requires firm to present valid DENR clearances prior to importation.	Firms secure importation clearances
The Pollution Control Law (Presidential Decree No. 984) and DENR Administrative Order Nos. 34 and 35	<p>Firms required to secure “Authority to Construct” and “Permit to Operate” Wastewater Treatment Facility if there is no centralized facility provided by IEs for wastewater.</p> <p>Firms required to submit monitoring reports to EMB cc: IE</p> <p>Effluent of firm should comply with DAO 35 except for IEs with centralized WTPs that can accommodate industrial process wastewater whereby interim standards are set by the IE operator.</p> <p>Semicon/electronic firm with wastewater from production is required to pre-treat hazardous component of wastewater prior to discharge into the centralized WTP.</p> <p>Conveyance or sewerage fee is charged by IE with centralized WTP.</p> <p>PEZA assists DENR in monitoring environmental compliance of locators and imposes administrative sanctions against violators.</p>	<p>Firms required to put up their own WTP and secure “Authority to Construct” and “Permit to Operate” from DENR.</p> <p>Firms required to submit monitoring reports to EMB</p> <p>Non-compliance results to imposition of penalties/fines by DENR.</p>
LLDA Resolution No.25	<p>Firms are required to secure a “Discharge Permit” which is computed based on the volume and BOD of effluent.</p> <p>Firms that discharge all wastewater into a centralized WTP of IE do not need to apply.</p> <p>PEZA assists LLDA in monitoring environmental compliance of locators and imposes administrative sanctions against violators.</p>	<p>Firms are required to secure “Discharge Permit”</p> <p>Non-compliance with DAO 35 results to imposition of penalties/fines by LLDA.</p>

Table 3. (concluded)

EIS System (Presidential Decree 1586) and DENR Administrative Order No., 96-37	<p>Firms required to secure ECC and present to PEZA upon registration.</p> <p>DENR conducts monitoring of compliance with ECC conditions.</p> <p>PEZA assists DENR in monitoring compliance of firm.</p>	<p>Firms required to secure ECC.</p> <p>DENR conducts monitoring of compliance with ECC conditions.</p>
Philippine Clean Air Act of 1999 (RA No. 8749)	<p>Firms required to install appropriate air pollution control devices and secure a “Permit to Operate” such with the DENR-Regional Offices.</p> <p>Firms submit quarterly monitoring report to DENR cc:IE</p>	<p>Firms required to install appropriate air pollution control devices and secure a “Permit to Operate” such with the DENR-Regional Offices.</p> <p>Firms submit quarterly monitoring report to DENR.</p>

Environmental laws are uniformly implemented among all locators, whether located within or outside an industrial estate as shown in Table 3. Under the existing laws, there is no distinction in compliance requirements for locators in an IE, except for the additional clearances required by PEZA and the IE itself prior to transport of hazardous wastes. As stated in Table 4, regulatory permits and reports are submitted to DENR, environmental unit of the IE and to PEZA. In addition to the annual inspection of DENR, on-the-spot random compliance inspection is also conducted by PEZA for locators inside an IE. Whenever locators are found to violate regulations, PEZA only give administrative sanctions whereas DENR imposes penalties and even closure of the locator. In terms of frequency of inspection, DENR and LLDA conducts monitoring at least once a year to all locators, except in instances where a complaint was filed against the locator or where violations were previously found to warrant more frequent sampling and follow-up inspections. The locators inside IEs are also monitored by PEZA annually.

Locators have the option to store hazardous wastes on site since there is no hazardous waste treatment facility in the Philippines. Some locators prefer to hire an environmental service provider (ESP) for the transport, treatment and disposal of their hazardous waste. The storage and disposal procedures should follow the requirements under RA6969 as shown in Table 5. Inside an IE, each locator has to adopt additional precautionary principles in the storage, transport and disposal of the wastes. The hazardous waste manifest form and clearances from DENR are strictly required by PEZA from the locators.



Table 4. Inspection and Monitoring of Hazardous Wastes of Firms Located Inside and Outside IEs

<i>Inspection Parameters</i>	<i>Applicability to Firms Inside IE</i>	<i>Applicability to Firms Outside IE</i>
Frequency of Inspection	Annual frequency by PEZA At least once a year by DENR PEZA conducts site inspection once a year. However, for locators with violations on environmental laws, inspection is conducted as often as needed until such time that the non-compliance is corrected.	At least once a year by DENR or LLDA, except when there violation(s) of the regulations where more frequent monitoring and sampling will be necessary.
Method of Inspection	DENR/LLDA conducts plant inspection and sampling if necessary.  DENR requires submission of quarterly hazardous waste monitoring report.  PEZA conducts ocular inspections focusing on the following: <ul style="list-style-type: none"> <li>• Process flow</li> <li>• Chemicals being used for each process</li> <li>• Chemical storage area</li> <li>• Waste storage area</li> <li>• Waste discharges</li> <li>• Working conditions</li> </ul>	DENR/LLDA conducts plant inspection and sampling if necessary.  DENR requires submission of quarterly hazardous waste monitoring report.
Use/Entry of Toxic Substances	Importation clearance required by EMB.  PEZA requires clearance from Safety Division to consider the following factors: <ul style="list-style-type: none"> <li>• Availability of Material Safety Data Sheet</li> <li>• Method of Use</li> </ul>	Importation clearance required by EMB
Reporting Mechanism	Firms submit hazardous waste quarterly report to EMB cc: IE/PEZA	Firms submit hazardous waste quarterly report to EMB.

Table 5. Storage and Disposal of Hazardous Wastes of Firms Located Inside and Outside IEs

<i>Parameters</i>	<i>Applicability to Firms Inside IE</i>	<i>Applicability to Firms Outside IE</i>
On-site storage	<p>Firms are required by PEZA to collect their hazardous waste and provide an appropriate storage facility</p> <p>IE/PEZA requires firms to undertake/observe the following:</p> <ul style="list-style-type: none"> <li>• Proper labeling of waste</li> <li>• Containers should be in good condition</li> <li>• Hazardous waste containers should be protected from direct heat and should be shielded from rain.</li> </ul>	<p>Firms should comply with storage requirements under RA6969</p>
Contracting of ESPs	<p>ESPs to be contracted by firm should undertake annual registration with DENR-EMB and should present the following documents to IE/PEZA:</p> <ul style="list-style-type: none"> <li>• ECC</li> <li>• Permit to Operate</li> <li>• Treatment technology and detailed process flow</li> <li>• EMB certification as transporter/treater/exporter</li> </ul>	<p>Use of ESPs by firms is optional, depending on the capability of the firm to handle its waste.</p>
Documentation Procedure for Disposal	<ul style="list-style-type: none"> <li>• Firm is required to fill up the hazardous waste manifest</li> <li>• Transporter should have a Permit to Transport from DENR-EMB.</li> <li>• Clearance from IE/PEZA is required when transporting waste from premises.</li> </ul>	<ul style="list-style-type: none"> <li>• Firm is required to fill up the hazardous waste manifest</li> <li>• Transporter should have a Permit to Transport from DENR-EMB.</li> </ul>

## 4.0 CONCEPTUAL FRAMEWORK

### 4.1 Analysis of Hazardous Waste Determinants in the Semiconductor and Electronics Industry

The model developed relies on the premise that the hazardous waste generation of semiconductor and electronic firms (SEF) is dependent on the internal and external pressures exerted by various stakeholders. By describing and analyzing the situation where the SEF operate, the key pressures and possible directions for their behaviour will be uncovered and predicted. Because the industries do not exist in a vacuum, i.e., they are intimately connected to a range of stakeholders and to society at large, it is vital that they are studied within the intra-organizational context.

In order to delineate some structure to this ‘environment’, a stakeholder analysis is performed. Here, stakeholders are defined as those likely to affect and be affected by the environmental performance of SEF. “task” environment (i.e., those that directly affect the organization). Examination of the broader “contextual” environment is done through PEST analysis (i.e., analysis of political, economic, social and technological pressures) which may impact key stakeholders belonging to the industries. This grouping of stakeholders and their corresponding pressures is illustrated in Figure 4, while their influence on the generation of hazardous waste of SEF is discussed in the foregoing sections.

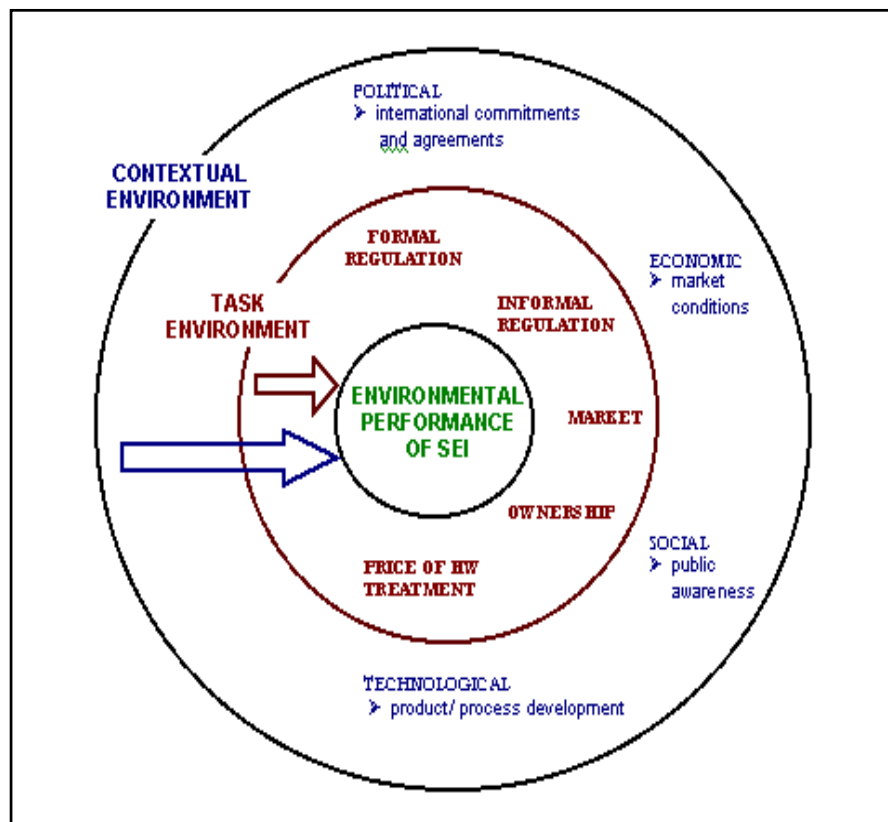


Figure 4. Stakeholders and Situations Affecting Hazardous Waste Management in SEFs

## **4.2 Task Environment**

In the immediate context of the semiconductor and electronic industries, different stakeholders have much contact with and impact on their environmental performance. These stakeholders are classified under the ‘task’ environment and the issues under review are regulations, market, ownership, and price of hazardous waste treatment. The following is a description and rationale for selection of each factor, identifying the type and the pressure or influence each has on the hazardous waste management of SEF as represented by their corresponding indices selected to represent the same.

### **4.2.1 Regulations**

A company’s environmental performance is greatly influenced by the regulations and their implementation. In a regime where formal regulations do not exist, industries have a tendency to ignore the pollution so as not to incur additional costs. In some cases, however, industries consider dilution as a solution when pollution becomes evident in terms of air emitted, wastewater discharged or volume of solid waste produced in order to minimize public clamour.

But in the presence of regulations and standards, the industries are forced to adopt pollution prevention or control measures in order to avoid penalties associated with non-compliance with the specified limits. Thus, past studies reveal that regulations, both formal and informal, have statistically important positive effects on pollution abatement activity (Hartman et al. 1997).

### **4.2.2 Informal Regulatory Pressures**

Informal regulation is defined as the capability of civil societies and local communities to foster collective actions against polluters. Where formal regulations are present, communities use the political process to influence the strictness of enforcement. Where regulations are absent or ineffective, non-government organizations (NGOs) and community groups – including religious institutions, social organizations, citizens’ movements, and politicians – pursue informal regulation by pressuring polluters to conform to social norms (World Bank 1999).

Hartman, et al. identifies that community income is a key determinant of informal regulatory outcomes. Apparently, communities whose residents are mostly poor, poorly educated or members of marginalized minority groups may have little ability to use the available channels of informal regulation. In estimating the severity of “environmental injustice”, per capita income is used as a proxy for political awareness, literacy, activism and political power.

Another form in which informal regulation is exercised is in industrial association membership. The association provides a venue for checking the compliance status of each and every member industry. It also provides exchange of information among the members with regard to issues affecting the industry.

### **4.2.3 Formal Regulatory Pressures**

Hazardous waste management in the Philippines is subject to specific regulations, standards and requirements enforced by the DENR (refer to discussions on hazardous waste regulations under Section 3). Among the requirements set by the DENR of hazardous waste generators is the responsibility to notify the former of the

type and quantity of wastes generated accompanied by a payment of the prescribed fee. They should also provide the DENR with information on a quarterly basis that includes the type and quantity of the hazardous waste generated, produced or transported outside, among other information required (DENR DAO 29 1992).

To strengthen the enforcement of such regulation, the DENR explores possible partnership among local government units and industrial estate administrations. If partnership is possible, local ordinances and special regulations are adopted in addition to national regulations. The extent to which the volume and type of hazardous waste generated is therefore affected by the presence of regulations at the local level, as well as the severity of the same.

#### **4.2.4 Market**

It is commonly said that industries in developing countries like the Philippines do not have incentives to invest in pollution prevention and control effort because of weak monitoring and enforcement of environmental regulations. Where technologies are barely available and affordable, industries are more likely to risk the possibility of paying penalties for not complying with or exceeding the specified pollution limits. This is considered more cost-efficient considering the huge investments required in pollution prevention and/or control compared and the probability of being caught, given the irregularity and often anomalous implementation of regulations.

This argument, however, assumes that the environmental regulator is the only agent that can penalize the firm lacking pollution control effort, or reward the firm for good environmental performance. It ignores the fact that the capital and consumer markets may react *negatively* to the announcement of adverse environmental incidents or *positively* to the announcement of better environmental performance (Dasgupta et al. 1997).

The impact of firm-specific environmental news on the market may work its way through various channels: a high level of pollution intensity may signal to investors the inefficiency of the firm's production process; it may invite stricter scrutiny by environmental groups and/or consumer associations; it may result in the loss of reputation, goodwill, and others. On the other hand, the announcement of a good environmental performance may have a positive effect: lesser scrutiny by regulators, communities, civil societies, and/or customer associations, greater access to international markets, and attractiveness to potential investors.

In the case of the Philippines where only a few semiconductor and electronic industries are listed and traded in the capital market, it is inappropriate at this time to compare the marketability (i.e., the ups and downs on the prices of their shares) of the companies themselves. Instead, the accessibility of these industries to the global market will be used in determining whether reputation really matters to them.

#### **4.2.5 Ownership**

At the onset, the research team believes that ownership would be among the determinants of hazardous waste generation in the semiconductor and electronics industry. This is because of the observable trend that companies partly or wholly owned by foreign nationals are mostly going beyond compliance with respect to environmental regulations (and thus, have relatively more pollution prevention efforts), due to the pressures imposed by their mother companies. Such pressures

originate from the internal regulations of these foreign companies to meet world-class standards.

Take the oil industry, for example. The lack of manpower and technology caused the government to minimize its monitoring function at the refining level on the understanding that the oil companies (only Shell, Caltex and Petron at that time) were subject to higher regulations imposed by their mother companies. Shell (owned by Royal Dutch, UK), Caltex (by Texaco, USA), and Petron (by Aramco of Saudi Arabia) in the Philippines are refining not only for the domestic market but also cater to their branches in Singapore (known as petroleum hub of the Asia-Pacific region), whenever a shortage occurs. Therefore, there is a need for these companies to meet global standards on petroleum refining.

At the same time, with the growing demand for EMS and/or ISO certification, multinational companies urge their local subsidiaries to be certified as well. The certification can be considered as a marketing strategy, wherein it is promoted as a guarantee for an “environmentally-responsible management”.

#### **4.2.6 Cost of Hazardous Waste Treatment**

In economics, price determines the demand for any particular product. Such price, when factored into the budget equation, determines the optimal level of demand for the product.

Given the volume and toxicity of hazardous waste generated in the semiconductor and electronic industries, the DENR requires the engagement of accredited environmental service providers (ESPs) with respect to treatment and disposal of such waste. The treatment cost charged by ESPs, however, is determined by various factors such as the required technology, disposal options availability, and administrative costs among others. For ESPs, semiconductor and electronic industries is a sure market; it is just a matter of charging the appropriate price.

The mandatory engagement of ESPs gives only two options to the said industries as far as their cost equation is concerned: (1) engage an ESP that charges a relatively low price; or (2) reduce the volume and toxicity of the hazardous waste generated. In a market where only a few suppliers of the same product are present, there is a high potential for ESPs to form a cartel and thus prices might be more or less the same among them.

### **4.3 Contextual Environment (using PEST Analysis)**

Is the external environment in which the SEFs are operating, change so fast and is the extent of its influence to their stakeholders evident enough to affect their environmental performance? In order to answer this question, we need to identify and examine the possible external factors that the SEFs have no, or have least control of, but could somehow affect the behaviour of their stakeholders in terms of putting pressures on their hazardous waste management.

In order to assess the relationship between these factors and how they influence the stakeholders, a PEST approach (Payne et al. 1996) is used in analysing the political economic, social and technological forces. The relative degree of pressure, stability and turbulence in these forces are also considered (Hall 1998).

#### **4.3.1 Political/Legal**

The Philippines is a party to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. Among its provisions, the Basel Convention permits the export of hazardous waste only if the exporting country lacks adequate facilities for proper disposal, or if the wastes are to be used as raw material in recycling or recovery operations.

Under the Convention, countries like the Philippines with no or less capability to process hazardous waste should enter into a bilateral agreement with the host country for the shipment processing of the same. As such, the government has been in deep discussions with the United States since 1998 for the shipment of hazardous wastes for recycling.

In September 2001, an agreement was signed between the two countries, allowing local electronic and semiconductor companies to ship hazardous industrial waste to the US. The agreement would resolve a long-standing issue on the recycling and proper disposal of hazardous wastes stockpiled by firms producing microprocessors in the Philippines (PDI 26 Oct 2001).

#### **4.3.2 Economic**

The Philippine economy recorded a 3.7% growth in gross domestic product in 2001 amidst political turmoil. The growth took place during a turbulent period--the storming of Malacañang by mobs on May 1, the close Senate election results, a surge of kidnappings and hostage-takings, and political disturbances stemming from the plunder trial of former President Joseph Estrada. The administration welcomed the growth as a "sure sign" of economic turnaround and a return of business confidence (PDI 09 Jan 2002).

However, such economic performance was brought about by the growth in construction, agriculture and manufacturing. Electronic exports, representing two-thirds of export earnings, dropped by 2.5% in the same year (NSO 2002). Given that the Philippine market is contracting in the United States and Europe for electronics products, it is further expected that electronics exports, and thus production, will continue to decrease as a result of economic downturn in the two countries following the September 11 attack.

Another factor to consider is the drop in consumer spending in high-tech products, which drags down demand for electronic components worldwide. An "over-inventory" of PC, telecommunications equipment and other electronic products in the Philippine market is a result of sudden increase in demand for these products during year 2000 (PDI 03 Aug 2001). Therefore, companies operating in the Philippines have resorted to "cost-reduction" efforts and some "retooling" to survive due to the global slowdown for demand of electronics, to the extent of cutting down working days from 6 to 4, while others had to lay off people.

Texas Instruments Philippines, Texas Instruments' biggest and most productive outfit accounting for nearly 50 percent of the group's US\$12-billion annual sales, for example. It is acknowledged worldwide as the producer of digital signal processors (DSP) used in all Nokia phones, 80% of Ericsson phones and 60% of Motorola phones. However, it has decided to defer back its US\$100-million expansion project at the Baguio City economic zone scheduled in 2001 due to the uncertain outlook on the electronics industry. The project would have expanded the

company's production of semiconductor and other materials used for broadband, switching, and Internet equipment. The company has also implemented an early retirement program that trimmed down five percent of its workforce in order to keep a leaner organization in the wake of the market downturn (PDI 23 Oct 2001).

### **4.3.3 Social Awareness and ISO/EMS Certification**

The growing public awareness on environmental issues lead to a number of global, national and local strategies to promote clean production and pollution prevention. Such strategies include eco-labelling (like EcoSeal, ISO, etc.) as well as product rating and endorsement (like PROPER ratings). There are anti-trade arguments and controversies on the use of product labels and thus, continuous efforts in harmonizing such standards are pursued. As an alternative, many industries begin to establish an environmental management system (EMS).

An Environmental Management System (EMS) is a systematic approach to environmental care in all aspects of business. Implementation of this approach is normally voluntary though certain systems (ISO 14001 and EMAS) can be certified if verified by an independent third party. The aim is not only to comply with environmental regulations and minimise the financial risks of liabilities and costs, but to improve the environmental performance continuously in order to improve corporate image and to gain competitive advantage.<sup>1</sup>

An EMS is a planned and coordinated set of management actions, operating procedures, documentation and record keeping, implemented by a specific organisational structure with defined responsibilities, accountabilities and resources. The specific system that is implemented depends on the needs and objectives of the organisation.

The decision to develop an EMS and having it certified may be driven by either defensive or offensive motives (or a mixture of the two). Obtaining ISO 14001-certification or EMS registration can either be a simple reaction to coercive pressure from powerful customers wishing to project a proactive environmental profile of their own. For example, if IBM or Acer requires that their suppliers must be ISO 14001 certified, semiconductor and electronic companies currently supplying or have interests to do the same in the future will undoubtedly react by trying to obtain the certification in order to retain or strengthen their market positions. At the same time, the decision can be a proactive strategy in which having a certification is to project a "green" image that could expand the company's opportunity for growth or profit. For example, an SEF may not be supplying to any companies that require ISO certification but would like to get the same for the purpose of conveying a clear message that it strives to improve efficiency and reduce its environmental impacts, while reducing costs and liabilities. As such, the ISO certification serves as a guarantee to its customers that the company has a self-monitoring capability that is at par with any other companies at the global market in pursuing its commitment.

In either of the two cases, the company is committed to the same objective i.e, continuous improvement of its environmental performance. Therefore, in the presence or absence of an appropriate hazardous waste management regulation, the ISO certification is a contributing factor on the level of waste that the company generates.

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<sup>1</sup> UNEP/ICC/FIDIC Training Kit, 1995



#### 4.3.4 Technology

The demand for semiconductor and electronic products is also dependent on the trend in technologies requiring such products as inputs. In general, there is a continuing upward trend in information technology development and therefore, a bright spot for the industry. For example, the automotive and digital imaging markets increased demand for electronic components in 2001.

Technologies that incorporate prevention, minimize waste, promote on-site recycling, and encourage energy conservation and water conservation are being promoted in the semiconductor and electronics industry. Likewise, technologies for off-site recycling, treatment, and disposal facilities should as much as feasible be environmentally sound. A semiconductor company that is ISO-certified or eyeing to become one has the following environment program goals:

- Prevent pollution and minimize waste
- Recycle wastes on-site or off-site
- Effectively treat or dispose of residual wastes in a cost-effective manner
- Assure costs are competitive with similar companies
- Maintain good relationships with government, communities, and workers

It is possible for a company to meet these economic goals and environmental goals at the same time. There was a time in the United States when some people thought of making a choice between economic development and environmental protection. Some argued that environmental controls would slow economic growth. But this turned out to be a false perception. It was realized that high environmental standards actually foster economic growth. Companies in the United States have proven that economic incentives, environmental incentives, and technological innovation can be aligned so that economic growth improves rather than diminishes environmental quality.

Basically, the three fundamental aspects of hazardous waste treatment are: (1) Removal of toxics, (2) Destruction of toxics, and (3) Immobilization of toxics. The selection of a treatment process depends highly on the physical form of the waste, major chemical components and the toxics of concern. The goal of treatment depends on economic and regulatory factors as well as risk from managing residuals and from operating the technology. Volume of wastes also plays a significant role. Chemistry of the constituent in the waste and in the environment is sometimes ignored but often helps make the right decision in treatment and management.

## 5.0 DEVELOPMENT OF THE MODEL AND QUESTIONNAIRE

### 5.1 Empirical Model and its Variables

The environmental performance indicator *amount of hazardous waste generated per employee* was selected since it is the main environmental problem of SEF and it can be a surrogate of environmental performance when the volume generated has been reduced by way of treatment, disposal or waste minimization

Table 6. Environmental Performance Indicator and the Explanatory Variables Used in the Model

**HWEMPL = f (PRICE, TRNG, LOC, INSP, ISO, OWN, MEM, REPFREQ, PROD, MARKET)**

HWEMPL	Amount of hazardous waste generated by the SEF per employee, kg/employee
PRICE	Price of treatment, transport and disposal of hazardous waste, US\$/kg
TRNG	Total person-hours of environmental training acquired by the SEF employees
LOC	Location of the SEF: 1 if located inside an industrial estate; 0 otherwise
INSP	Accumulated number of inspections conducted by environmental agencies for the last 2 years
ISO	Presence of ISO certification: 1 if EMS/ISO 14000 or 9000 certified, 0 otherwise
OWN	Percentage of foreign ownership in the SEF
MEM	Membership in industrial association: 1 if affiliated or member in an industrial association; 0 otherwise
REPFREQ	Percentage of self-reporting compliance
PROD	Type of product: 1 if semiconductor; 0 otherwise
MARKET	Percentage of products sold to the export market

efforts. The explanatory variables in Table 6 were selected based on their potential effect on the hazardous waste generation. The reference year used was 2000 since this is the only year with complete data.

## 5.2 Design of Questionnaire and Pre-testing

The survey questionnaire was developed in consultation with the inter-agency advisory committee and was pre-tested using locators and zone managers in three industrial estates. Thereafter, it was revised two times to reflect the improvement that needs to be made as well as for easy data encoding and processing into the MS Access database.

The survey questionnaire generated the following information:

- a) Amount of hazardous waste generated
- b) Ownership in terms of percentage owned by Filipino nationals, multinational corporations, and foreign nationals
- c) Size of plant measured by the total number of employees in its full capacity
- d) Classification of the industry's market whether product is exported or sold to export-related firms
- e) Environmental training provided to employees
- f) Price of treatment, transport and disposal of hazardous waste
- g) Location of the firm whether inside or outside an industrial estate
- h) Membership in an industrial association

- i) Type of product produced
- j) ISO certification
- k) Reporting frequency

To this database, the research team has added the following information about economic and regulatory environment in which the industries operate:

- a) Frequency of visits or inspection
- b) ISO/EMS certification
- c) Self-reporting requirements and compliance

A series of descriptive and quantitative analyses was done to determine which among these variables can explain the variations in the environmental performance of SEFs as measured by the dependent variable amount of hazardous waste generated by the SEF per employee.

## **6.0 DATA COLLECTION**

The total population of semiconductor and electronics industry in Luzon is 522, of which 347 are located inside IEs and 175 are located outside IEs. The total number of samples of SEF inside IEs that was considered for this study is 100. These were selected at random as representative samples for the survey as they represent about 30% of the SEF found inside the IEs. Only those in Luzon were included in the study since 90% of total SEF are found in Luzon.

The random sampling was carried out using Random Tool of MS Excel. This computer random sampling is like writing the name of each SEF in a tiny paper and putting them all in a basket to be drawn one by one at random. In this case, we placed all the encoded names of the SEF (347 located inside IEs) in one large Excel spreadsheet file and the computer generated 100 random numbers or codes. Afterwards, we matched the actual names of the firms and identified the respective industrial estates where they belong. The 100 samples came from 17 industrial estates in Luzon, which are shown in Figure 2. Of these, 57 survey sheets were obtained but only 48 had complete data to be useful for analysis.

The sample size for SEF outside IEs was also 100. However, many of the firms in the list of random samples were no longer operational or have moved out to another country. Most of them manufacture electrical appliances and are not SEFs per se. Only 6 sample firms located outside IEs were able to provide complete data for the analysis. It was difficult to elicit cooperation from the firms outside the industrial estates.

The information needed for the model was obtained by means of a survey questionnaire among the various locators and firms. Additional data was solicited from the members of the Inter-agency advisory committee composed of DENR-EMB, PEZA, LLDA, DTI/BOI, SEIPI, and PCAPI. The PEZA management and their

regional offices provided the much-needed support in setting up schedules for the survey. Originally, it was intended to conduct one-on-one surveys but the ecozone administrators suggested to carry out a workshop-style approach where all the randomly selected locators are convened in a conference room for each industrial estate. For every workshop, a 30-minute presentation was given about environmental performance evaluation along with an explanation about the study and the survey. Handouts of project summary and the questionnaire were distributed ahead of time. Thereafter, as in a classroom style, the locators were requested to fill up the questionnaire, usually lasting about 20-30 minutes each. The project team was available to answer questions or to clarify the questions and the required answers.

## 7.0 RESULTS AND DISCUSSION

### 7.1 Descriptive Analysis of the Data Set

Initial assumptions made in developing the model are examined using the data collected during the survey. The characteristics of each explanatory variable – namely, number of employees, price of hazardous waste treatment, location (whether inside or outside an IE), inspection frequency, training, ISO/EMS certification, industrial association membership, type of product, and reporting frequency – is described in relation to the dependent variable, which is the amount of hazardous waste generated by an SEF per employee.

#### *a. Employees*

Considering that the SEF is a labor-intensive industry and its production size increases in proportion to its employees, the number of employees is then used as a proxy to determine the firm's hazardous waste performance. Table 7 shows the comparison of such performance among small, medium and large-sized semicon and electronic firms. It should be noted, however, that the size classification used in this discussion is purely based on the number of employees rather than on capitalization.

Table 7. Number of Employees in SEFs and Hazardous Waste Generation

<i>No. of Employees in SEI</i>	<i>Minimum Amount of HW</i>	<i>Maximum Amount of HW</i>	<i>Mean Amount of HW</i>	<i>Median</i>
Small: less than 1000 (sample size of 27)	120	74619	14771	5589
Medium: 1000 to 3000 (sample size of 14)	1620	169510	48610	32601
Large: more than 3000 (sample size of 7)	13000	104943	67135	80560

It can be noticed from the minimum and mean values that the number of employees significantly affects the amount of hazardous waste generated in a semicon firm. As the firm expands its operation and thus, additional labor inputs are required, there is a high tendency that such firm generates more wastes. However, it can also be noted that even as the firm increases its number of employees, there is a certain stage where the amount of hazardous waste generated levels off, as it can be seen in the maximum values.

***b. Price of Treatment***

The survey generated different units used in calculating the price of treatment incurred by the sample SEFs. As such, the values were normalized by converting them into a uniform unit (e.g., cubic meter, where containers are used, estimated in terms of kilograms) and derived the per kilogram treatment price. The price data ranges from as low as \$0.0943 per kg to as high as \$0.5798. Table 8 describes the amount of hazardous waste generated in terms of differences in treatment prices.

Table 8. Treatment Price and Hazardous Waste Generation

<i>Price Ranges</i>	<i>Minimum Amount of HW</i>	<i>Maximum Amount of HW</i>	<i>Mean Amount of HW</i>	<i>Median</i>
Less than \$0.30 per kg (sample size of 23)	5388	169510	53790	58270
\$0.30 to \$0.40 per kg (sample size of 10)	12008	102925	25918	19330
Greater than \$0.40 per kg (sample size of 15)	120	22000	3530	2400

Table 8 clearly shows that as treatment price increases, the amount of waste generated decreases. Therefore, price is an effective instrument to enhance the environmental performance of SEFs. Its price elasticity of  $-2.87$  using log-linear equation also reveals that a 1% increase in the price of treatment could result to a 2.87% decrease in the average hazardous waste generation among SEFs.

***c. Location and Type of Ownership***

A glance at the existing IE policies administered by the Philippine Economic Zone Authority (PEZA) will lead to one's conclusion that SEFs located inside an industrial estate performs better compared to those outside the estate. Table 9 examines this condition and describes their respective behaviors.

Table 9. SEF Locations and Hazardous Waste Generation

<i>Location</i>	<i>Minimum Amount of HW</i>	<i>Maximum Amount of HW</i>	<i>Mean Amount of HW</i>	<i>Median</i>
Inside IE (sample size of 42)	125	169510	32391	15830
Outside IE (sample size of 6)	120	81660	31481	23867

The data failed to validate the initial hypothesis. SEFs located inside IEs produce more hazardous waste than those that are located outside IEs. The variation may be due to the lack of data generated from the samples outside IEs. Because of the improved services and facilities offered in IEs, more of the export-earning investments like the SEFs are now transferring to IEs.

The impact of the type of ownership of the IEs, i.e., whether public or private, was further evaluated as shown in Table 10.

Table 10. Hazardous Waste Generation by IE Ownership

<i>Location</i>	<i>Minimum Amount of HW</i>	<i>Maximum Amount of HW</i>	<i>Mean Amount of HW</i>	<i>Median</i>
Public IE	125	169,510	35,254	10,435
Private IE	400	80,100	32,391	20,000

As with the results gathered for location of SEF, IE ownership does not give a valid confirmation that there is difference in environmental performance of SEFs located in a public owned or private owned IE. This may be attributed to the standardized guidelines and regulations imposed by PEZA and DENR for both public and private IEs as well as its locators.

#### ***d. Inspection Frequency***

Inspection frequency is initially assumed to influence the environmental performance of SEFs, where more frequent inspections could drive SEFs to improve or reduce its hazardous waste generation. It is so because in the semiconductor and electronic industry, inspection is done at random. Although there is no standard or limit on the amount of hazardous waste generated (unlike in air emission or wastewater discharge), inspection frequency does not primarily rely on the reports submitted by SEFs rather, on the complaints received by the EMB from affected stakeholders.

Given its relatively more organized structure, on the other hand, the industry is being inspected less compared with other types of industries (like medical and pharmaceutical industries). As such, only 2 inspections at the maximum are made to SEFs for the past two years. Table 11 shows the relationship between inspection frequency and hazardous waste generation among SEFs.

The data indicated that 8% of SEFs was not inspected, 62% was inspected once, and 30% were inspected more than once in the past two years. In terms of hazardous waste generation, those monitored more than once produced 54% less hazardous waste than those monitored only once, based on the average values. As for “no inspection” and “once inspection”, it seems that there is no difference at all as far as the waste generated among SEFs is concerned, as shown in their mean and median values.

Table 11. Hazardous Waste Generation and Frequency of Inspection

<i>Inspections</i>	<i>Min HW</i>	<i>Max HW</i>	<i>Mean HW</i>	<i>Median HW</i>
No inspection (sample size of 4)	4000	103350	37377	21080
Once (sample size of 30)	120	169510	38354	22428
more than once (sample size of 14)	125	81660	17798	6364

#### *e. Training*

At the onset, it is assumed that environmental training among employees enhances the overall environmental performance of SEFs. As such, the effect of this training in terms of man-hours that SEF employees acquired is validated under the survey and is presented in Table 12.

Table 12. Hazardous Waste Generation of SEF and Man-hours of Training

<i>Man-hours of Training</i>	<i>Min HW</i>	<i>Max HW</i>	<i>Mean HW</i>	<i>Median HW</i>
less than 80 hours (sample size of 24)	120	103350	26152	10881
80 to 300 hours (sample size of 16)	400	169510	37585	16500
more than 300 hours (sample size of 8)	2400	104943	40039	23000

It appears from the results that employee training on environmental management has no effect on the degree of environmental performance of the SEF. Contrary to the initial assumption, greater hazardous waste is generated by SEFs providing more training than those that offer lesser training opportunities. Most of the training opportunities are given to pollution control officers and some technical staff directly involved in the operation of the waste management system. Those firms investing more on training probably felt the need to know more waste minimization or cleaner production to reduce their waste.

***f. ISO/EMS Certification***

Certification to the International Standard Organization and/or environmental management system is expected to yield better performance among firms, as these systems ensure compliance with existing environmental regulations and standards. Therefore, it is believed that SEFs with these types of certifications are relatively polluting less. Table 13 shows the comparison of hazardous waste generated by semiconductor and electronic firms with ISO/EMS certification with those without. Many companies though generating more hazardous waste are also environmentally compliant.

Table 13. Hazardous Waste Generation and ISO Certification

<i>ISO/EMS Certification</i>	<i>Min HW</i>	<i>Max HW</i>	<i>Mean HW</i>	<i>Median HW</i>
No ISO Cert. (sample size of 19)	120	102,925	23,661	12,008
With ISO Cert. (sample size of 29)	125	169,510	37,922	22,160

Based on the data, it is inconclusive whether such assumption holds true, as it is in other industries. One possible explanation is that the intention of seeking certification is deeply-rooted in the objective of being competitive since most of the SEFs are in the global market. These certification systems is somehow perceived as a “harmonized” standard among global traders, in the light of differences in environmental policies in different countries.

***g. Industrial Association Membership***

A network or organization of SEFs is presumed as a potential tool that could be tapped to enhance environmental performance of member-companies. Existing organizations involving SEFs are the SEIPI and PCAPI. Table 14 details the relationship between hazardous waste generation and SEF membership in related organizations.



Table 14. Hazardous Waste Generation and SEF Membership in Organizations

<i>Membership</i>	<i>Min HW</i>	<i>Max HW</i>	<i>Mean HW</i>	<i>Median HW</i>
Not a member (sample size of 7)	2400	65100	17394	5600
Member (sample size of 41)	120	169510	34818	18660

The data indicates that membership in an organization is not a factor to improve environmental performance. Members in organization produce 50% more of the average hazardous waste generated by the samples than those that are not members in any organization. The disparity may be due to the fact that almost all of the SEFs are now members of SEIPI and PCAPI, as such membership is seen as a normal trend among SEFs.

#### ***h. Product Type***

The industry classification, under the Philippine standards, somehow gives sufficient flexibility. Semicon manufacturers are almost of the same level with those purely assembling semiconductor parts for electrical and electronic purposes. As such, the study attempted to examine the environmental performance of firms engaged in semiconductor manufacturing (based on their products) compared with the rest in the industry, as shown in Table 15.

Table 15. Product Type and Hazardous Waste Generation

<i>Product Type</i>	<i>Min HW</i>	<i>Max HW</i>	<i>Mean</i>	<i>Median</i>
Semiconductor (sample size of 44)	125	169510	33023	19330
Non-Semiconductor (sample size of 4)	120	81660	24075	7260

It can be seen from the above table that firms engaged in semiconductor manufacturing generate more hazardous waste compared with others that are not. This is because semiconductor manufacturers are prone to risk of having more rejects in production and are major source of mold runners. The intricate and minute components of such rejects, moreover, make it difficult for reusing the parts as inputs.

#### ***i. Reporting Frequency***

Under RA 6969 and its implementing rules and regulations, periodic reports should be submitted by the SEF to DENR, LLDA, or PEZA. The extent of environmental reporting of the SEF was presumed to affect performance, as it discloses all information pertaining to the quality and quantity of hazardous waste it

generates. Table 16 shows the frequency of reporting among SEFs and the amount of hazardous waste they generate.

It can be noticed from Table 16 that as more reports are submitted by the SEFs, the amount of hazardous waste they generate increases. Such inconsistency can be explained by the fact that report submission is viewed only as compliance on the part of the SEF and not an indication of performance. Also, the number of reports required for submission is also determined based on the type and volume of wastes.

Table 16. Hazardous Waste Generation and Frequency of Reporting among SEFs

<i>Reports Submitted</i>	<i>Min HW</i>	<i>Max HW</i>	<i>Mean HW</i>	<i>Median HW</i>
No reports (sample size of 12)	120	72115	16040	4044
With 1– 3 reports (sample size of 8)	125	102925	22064	12715
more than 3 reports (sample size of 28)	2043	169510	42154	23628

## 7.2 Regression Analysis

Using step-wise regression and correlation matrix, variables such as OWN, ISO, MEM, REPFREQ, and MARKET shown in Table 6 were found to have no correlation with the hazardous waste generation behavior of SEFs and are pulling down the overall significance. They were no longer considered in the succeeding regression analysis. In reality, this situation is acceptable since ownership does not differ much among the SEFs, the industry being capital-intensive thus, mostly foreign-owned. ISO 9000 and 14000 accreditation appear to be also common among the SEF as required by their mother companies abroad. SEIPI membership does not seem to make any difference, as most SEF locators join semiconductor and electronic industry association voluntarily. Most of the SEF export a significant amount of their products as reflected in PEZA statistics that they contribute around 60% of the country's exports. Reporting frequency, on the other hand, gives no bearing on how the SEF behave as far as their hazardous waste generation is concerned, since reporting itself is entirely dependent on the schedule of submission of waste inventory reports as required by RA 6969.

After eliminating the five insignificant variables, another first-stage regression analysis has been conducted with the results shown below.

**Descriptive Statistics Section**

Variable	Count	Mean	Standard Deviation
TRNG	45	146.942	169.256
PRICE	45	0.3527632	0.0889742
LOC	45	0.8772056	0.2758522
INSP	45	1.24315	0.4976114
ISO	45	0.6394547	0.4035723
PROD	45	0.901228	0.2507672
HWEMPL	45	18.79415	12.43739

**Regression Equation Section**

Independent Variable	Regression Coefficient	Standard Error	T-Value (Ho: B=0)	Prob Level	Decision (10%)
Intercept	59.20319	9.053286	6.5394	0.000000	Reject Ho
TRNG	2.003879E-03	7.783074E-03	0.2575	0.798208	Accept Ho
PRICE	-103.0613	14.97533	-6.8821	0.000000	Reject Ho
LOC	16.79385	5.402153	3.1087	0.003551	Reject Ho
INSP	-6.713125	2.591891	-2.5900	0.013532	Reject Ho
ISO	-7.502672	3.611269	-2.0776	0.044557	Reject Ho
PROD	-6.586452	6.597796	-0.9983	0.324458	Accept Ho
R-Squared	0.625196				

Notice that variables referring to the accumulated environmental training acquired by the SEF employees denoted by TRNG and type of products denoted by PROD are statistically insignificant at 10% confidence level. Regression analysis was then conducted, omitting these two variables one at a time. Second-stage robust regression, in which the variable TRNG has been dropped from the equation, was undertaken and yielded the following results:

**Descriptive Statistics Section**

Variable	Count	Mean	Standard Deviation
PRICE	45	0.3530727	8.922975E-02
LOC	45	0.8771265	0.2758297
INSP	45	1.244306	0.4976435
ISO	45	0.6375427	0.4038907
PROD	45	0.9021998	0.2495755
HWEMPL	45	18.72173	12.32756

**Regression Equation Section**

Independent Variable	Regression Coefficient	Standard Error	T-Value (Ho: B=0)	Prob Level	Decision (10%)
Intercept	58.28968	8.772465	6.6446	0.000000	Reject Ho
PRICE	-101.4057	14.42111	-7.0318	0.000000	Reject Ho
LOC	16.51977	5.253881	3.1443	0.003179	Reject Ho
INSP	-6.635281	2.506095	-2.6477	0.011635	Reject Ho
ISO	-7.420963	3.328748	-2.2294	0.031621	Reject Ho
PROD	-5.837738	6.412003	-0.9104	0.368184	Accept Ho
R-Squared	0.632113				

It can be noticed that the type of product, as denoted by PROD, is still statistically insignificant even though the TRNG variable has already been dropped from the equation. Third-stage robust regression, without both TRNG and PROD variables, was conducted and yielded the following results:

#### Descriptive Statistics Section

Variable	Count	Mean	Standard Deviation
PRICE	45	0.3518237	8.815336E-02
LOC	45	0.8815213	0.2708244
INSP	45	1.232296	0.4945875
ISO	45	0.6463622	0.4006531
HWEMPL	45	19.12226	12.46317

#### Regression Equation Section

Independent Variable	Regression Coefficient	Standard Error	T-Value (Ho: B=0)	Prob Level	Decision (10%)
Intercept	54.68672	6.957823	7.8597	0.000000	Reject Ho
PRICE	-100.3414	13.72003	-7.3135	0.000000	Reject Ho
LOC	14.59239	4.65688	3.1335	0.003229	Reject Ho
INSP	-6.075461	2.432059	-2.4981	0.016698	Reject Ho
ISO	-8.723792	3.10239	-2.8120	0.007593	Reject Ho
R-Squared	0.633851				

The regression analysis therefore yielded the following equation:

$$HWEMPL = 54.69 - 100.34 \text{ PRICE} + 14.59 \text{ LOC} - 6.08 \text{ INSP} - 8.72 \text{ ISO}$$

The intercept of 54.69 suggests that on the average, an SEF annually generates 54.69 kg of hazardous waste per employee. The coefficient of -100.34 for PRICE implies that a dollar increase in the price of treatment is expected to reduce hazardous waste generation by 100.34 kg per employee. The environmental performance of SEFs, denoted by HWEMPL, and the price of treatment, PRICE, are then isolated from the rest of the variables and transformed into a log-linear function to examine price responsiveness of SEFs. Price elasticity of -2.34 suggests that a 1% increase in the price of treatment for a kilogram of hazardous waste will result to a 2.34% reduction in the average hazardous waste generation per employee of the SEFs. The value in its absolute terms also implies that the environmental performance of SEFs is price elastic.

Location of the SEFs seems to contribute to their environmental performance. The coefficient of 14.59 suggests that SEFs located inside an ecozone tend to generate 14.59 kg per employee more than those located outside. Take note, however, that there is no limit with respect to the amount of hazardous waste that SEFs can generate and the most that is required of them is to submit report on their hazardous waste. The SEFs inside the zone are under closer scrutiny and are more transparent with their reports whereas those outside the ecozones are not.

The coefficient of  $-6.08$  for INSP suggests that for every additional inspection to be made by environmental agencies, SEFs tend to improve their environmental performance with a reduction on their hazardous waste generation by  $6.08$  kg per employee. The semicon and electronics industry is the sector least inspected since the SEFs have a good record of compliance to environmental regulations.

Lastly, EMS, EMAS and/or ISO certification seems to have significant contribution to the environmental performance of SEFs. The coefficient of  $-8.72$  for ISO suggests that SEFs with ISO certification generate lower hazardous waste of  $8.72$  kg per employee compared to those that have not. This can be attributed to the stringent conditions set on ISO certification, which includes systematic monitoring of environmental performance for the purpose of achieving improvements.

## 8.0 SUMMARY AND CONCLUSIONS

In the Philippines, the semiconductor and electronic industry contributes about 70% of export earnings. More than half of the companies inside industrial estates in the country are semiconductor and electronic firms. Currently there are approximately 576 firms – with 398 located inside industrial estates and 178 firms outside.

Semiconductor and electronic industries include the manufacturing of television sets, small electrical appliances, passive components, semiconductor components; printed circuit and printed wiring assemblies. These firms are among the major contributors of hazardous wastes released through different media, notably solid and semi-solid wastes.

The environmental performance indicator, amount of hazardous waste generated, was selected in this study since it is the main environmental problem of SEF and it can be a surrogate of environmental performance when the volume generated has been reduced by way of treatment, disposal or waste minimization efforts. There were 10 explanatory variables used in the analysis based on their potential effect on the hazardous waste generation. The reference year used was 2000 since this is the only year with complete data.

A model equation was derived which identifies the significant variables in terms of affecting the hazardous waste generation. The independent variables are a) ownership in terms of percentage owned by Filipino nationals, multinational corporations, and foreign nationals, b) accumulated number of inspections conducted by the environmental agencies for the last two years, c) classification of the industry's market whether product is exported or sold to export-related firms, d) environmental training provided to employees, e) price of treatment, transport and disposal of hazardous waste, f) location of the firm whether inside or outside an industrial estate, g) membership in an industrial association, h) type of product produced, i) ISO certification, and j) reporting frequency.

Out of the 10, only four were found to be significant to reduce or increase amount of hazardous waste generated. These are a) ISO accreditation, b) price of treatment and disposal, c) location of firm, whether inside an industrial estate or not, and, d) number/frequency of inspection by regulatory agency. From the regression results, it was shown that there would be less hazardous waste generation if the firm were more automated with less number of employees. Proper handling and transporting of raw materials and products to minimize waste, increasing quality

control to minimize rejects, and recycling could also reduce waste generation. Price has also an effect in that increasing the cost charged by ESPs could result to a substantial reduction in hazardous waste generation, which was found to be price elastic. The location of the SEF was also found to be a significant variable since SEF located inside an industrial estate produces more hazardous waste but perhaps because the SEFs inside the IEs are more transparent in reporting compared to their counterparts outside IEs. More frequent inspection was also shown to positively affect the environmental performance by reducing hazardous waste generation. Thus, as in other types of industry, inspection is a powerful tool in improving environmental performance within the semiconductor and electronic industry.

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## **APPENDIX 1 – LIST OF ABBREVIATIONS**

BOI	Board of Investments
DAO	DENR Administrative Order
DENR	Department of Environment and Natural Resources
DTI	Department of Trade and Industry
EIA	Environmental Impact Assessment
ECC	Environmental Compliance Certificate
EMB	Environment Management Bureau
EMS	Environmental Management System
EPI	Environmental Performance Index
ESPs	Environmental Service Providers
HWM	Hazardous Waste Management
IAC	Inter-Agency Advisory Committee
IDRC	International Development Research Centre
IE	Industrial Estate
ISO	International Organization for Standardization
JICA	Japan International Cooperation Agency
JBIC	Japan Bank for International Cooperation
LLDA	Laguna Lake Development Authority
PCAPI	Pollution Control Association of the Philippines Inc
PCBs	Polychlorinated Biphenyls
PD	Presidential Decree
PEZA	Philippine Economic Zone Authority
RA	Republic Act
SEC	Securities and Exchange Commission
SEF	Semiconductor and Electronics Firm
SEIPI	Semiconductor & Electronics Industry of the Philippines, Inc.
TSD	Treatment, Storage, and Disposal
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
UPD	University of the Philippines, Diliman
UPLB	University of the Philippines – Los Baños